THE OHIO JOURNAL OF SCIENCE

Vol. XXII DECEMBER, 1921 No. 2

FOOD OF THE COMMON OHIO DARTERS

CLARENCE L. TURNER
Zoological Laboratory, Beloit College

INTRODUCTION.

This paper constitutes one unit of a report of a fish survey of Ohio undertaken by the Ohio Bureau of Fish and Game and directed by Professor R. C. Osburn, of Ohio State University. It was the main purpose of this survey to determine the status of the game and food fishes in the various waters of the state. In the environmental conditions responsible for the production of game fishes the food plays an important role and in order to have all the factors governing the food conditions it is necessary to determine also the food and feeding habits of those animals which are themselves used as food by the game fishes. During their younger stages perch and darters, as well as the young of many other kinds of fish, furnish food for the young, yearling and older basses. A report has already been made upon the food and feeding habits of the young perch (Turner, 1920) and this report offers a similar study of the darters.

A part of the work was done at the Lake Laboratory of Ohio State University at Put-in-Bay during July of 1919 and the writer is greatly indebted to Director R. C. Osburn, who with his keen interest and long experience in fish problems, lent encouragement and advice. During the summer of 1920 Professor Osburn, L. H. Tiffany, E. L. Wickliff and W. C. Kraatz of Ohio State University, and the writer made extensive collections from all the larger lakes and reservoirs of the state as well as from some of the streams of central Ohio. Several thousands of darters were collected, comprising eleven different

species and ranging in size from ten to one hundred millimeters. Six hundred and twelve of these covering a wide range in locality, kind of habitat, date of capture and age of individual were examined.

METHODS.

All the measurements of length include the distance from the base of the caudal fin to the tip of the jaw or snout.

Very few specimens were examined in a fresh condition, nearly all being preserved in strong formalin as soon as taken.

Various kinds of seines were furnished by the Bureau of Fish and Game and practically all the fish were taken by seining.

In determining the quantity and character of the food the stomach and intestine were dissected out with the aid of a binocular microscope, the contents removed and, so far as possible, identified. A compound microscope was also employed for the identification of smaller objects, after which quantitative estimates of the various articles of food were made.

FOOD OF EACH SPECIES.

There is a general similarity in the food of the different species. The most typical feed almost exclusively in their younger stages upon entomostraca and minute midge larvæ, later increasing the amount of midge larvæ at the expense of the entomostraca. It is worthy of note that larger specimens of midge larvæ are taken as the fishes increase in size. Still later the young fishes turn to larger insect larvæ and this is their staple adult food. Forbes shows that the younger fishes of most families pass through these stages and then become more specialized as adults, eating fish, molluscs, vegetation or even one-celled organisms. Several variations from the generalized food habits occur among the darters and the details of such variations will be taken up in the discussion of each group.

A. **Percina caprodes** Rafinesque.

There is no question but that *Percina caprodes* and *P. caprodes* variety *zebra* appear in the collections but no distinction has been made here. Specimens were taken from Lake Erie, mainly at Put-in-Bay, many of the streams and from most of the inland lakes of the state. It was the most common and widely distributed of the whole group of darters. The specimens have been divided into three groups, those from Lake Erie, those from the streams and those from the inland lakes, as these seem to offer rather definite units of habitat.

TABLE 1.

Food of *Percina caprodes* from Lake Erie.

Length in mm.	23	24	25	26	27	28	29	30	32	33	34	36	37	39	40-50	50-60	60-70	70-80
No. examined	1	8	8	10	16	8	4	4	2	1	4	1	2	2	10	24	22	6
Articles of diet: Copepoda	100.	95.	70.	82.5	60.6	53.6	77.5	85.	95.	70.	25.	60.	87.	5.	10.7	7.7	4.2	
Cladocera		2.5	6.	10.	6.2	12.8	20.	5.			15.	40.	5.		27.7	.2	2.2	
Ostracoda				+		+												
Midge larvae			3.2	6.	8.5	8.2		10.			10.			75.	46.2	54.1	34.	21.
Amphipods		2.5				6.2									.5	18.3	16.8	40.1
May fly larvae			10.	1.5	6.2	7.55	1.5				50.		8.	20	1.	13.4	34.8	
Other insect larvae															12.5	2.5	4.5	20.
Snails																	.7	
Isopods																	.9	
Fish remains										10.					1.2			
Fish eggs																	.1	
Flat worms			1.			.2	.2									.6		
Round worms			.25				.2								.2	.5		
Annelid worms					4.5	11.2	.6		5.	20.								10.
Nauplius larvae			.25			.25												
Plant remains																3.2	1.8	6.3
Sand and silt																.5		2.6

TABLE 2.

Food of *Percina caprodes* from inland lakes.

Length in mm.	30–35	35–40	40–50	50–60	80–90	90–100
No. examined	1	4	3	2	4	2
Articles of diet: Copepoda			30.6	1.		
Cladocera		22.5	16.6		1.3	
Ostracoda						3.
Midge larvae	60.	29.5	29.3	96.5	26.6	7.5
Amphipods					6.6	20.
May fly larvae	38.	11.75	3.3	1.5	30.6	5.
Beetle larvae		15.			13.3	7.
Caddis fly larvae					6.	50.
Other insect larvae			20.2			
Fish remains		11.75				
Round worms	2.				4.	
Plant remains		9.5			4.3	.5
Bottom debris				1.	7.3	7.

TABLE 3.

Food of *Percina caprodes* from streams.

Length in mm.	25–30	30–35	35–40	40–50	50–60	60–70	70–80
No. examined	1	2	2	1	2	3	1
Articles of diet: Copepoda	15.		2.5		1.	2.4	
Cladocera			1.5		.5	1.	
Midge larvae		66.	90.	100.	52.	47.6	
May fly larvae	80.	34.	5.		45.	20.	88.
Caddis fly larvae					.5	11.4	11.
Snails						16.6	
Fish eggs	5.						
Flat worms						.3	
Sand and silt			1.		1.	.7	1.

The record of the Lake Erie specimens shows that there are three rather well-defined periods in the food habits. The youngest subsist almost entirely upon entomostraca although minute amphipods and midge larvæ are also taken to a limited extent. During the second period amphipods, insect larvæ and ento-

mostraca are eaten, with the insect larvæ and the amphipods gradually predominating. In the last stage the diet becomes very complex with the larger insect larvæ and amphipods furnishing the larger proportion of the food while the quantity of entomostraca becomes negligible. Although the quantity of entomostraca definitely decreases, a few are eaten even by the largest fish and an occasional individual is found which has eaten little else.

The specimens taken from the inland lakes were fewer in number but were more developed, none being smaller than 30 mm. The food habits of this group closely parallels that of the Lake Erie group but there is one outstanding, if minor, difference. Entomostraca do not play nearly so constant a part in the diet although there is a larger proportion eaten by the smaller fishes. It is to be noted that the waters of the inland lakes are much more concentrated in their production of insect food than those of Lake Erie and it is possible that the Lake Erie fish are compelled to rely upon Entomostraca in the absence of insect food.

Some interesting variations in food habits are offered by the fishes from the streams. 1. The food is less varied in the stream fish. 2. Entomostraca are eaten constantly but in a very small proportion while midge and May fly larvæ furnish almost the whole food in many cases. 3. Amphipods are wholly lacking in the food of the stream fishes. 4. There is a proportionately large amount of molluscan food taken. 5. Planorbis and Physa are the principal snails eaten by the specimens from Lake Erie while Ancylus is the only snail taken by the stream fishes.

Summary of Food Habits in Percina caprodes.

1. Younger specimens subsist mainly upon entomostraca. 2. Insect food and entomostraca are taken by the intermediate individuals. 3. The larger specimens have a more complicated diet but entomostraca are continued as a constant though small item and insect larvæ form the principal constituent. 4. Specimens from the inland lakes vary somewhat from the course followed by the Lake Erie specimens. 5. Fishes from the streams differ markedly in their food habits from those from Lake Erie and the inland lakes.

B. **Diplesion blennioides** Rafinesque.

This darter is well distributed and great numbers of them were taken in the streams throughout the state. A few of the older ones and a fair number of the younger ones were taken in the vicinity of the Bass Islands of Lake Erie. A few were taken from the inland lakes. Tables 4 and 5 illustrate the comparative food habits of the Lake Erie and the stream specimens. The data concerning those from the inland lakes was so scant as not to warrant a table.

TABLE 4.
Food of *Diplesion blennioides* from Lake Erie.

Length in mm.	15-20	20	21	22	23	25	28	33	36	55
No. examined	3	2	2	4	2	8	6	2	2	1
Articles of diet: Copepoda	3.33									
Cladocera	13.33					1.				
Ostracoda						.5				
Midge larvae	80.	100.	100.	70.	90.	85.	71.6	90.	100.	100.
May fly larvae				30.			6.4			
Beetle larvae					10.	12.	22.	10.		
Filamentous algae						.5				
Stones and silt	3.34					1.				

TABLE 5.
Food of *Diplesion blennioides* from streams.

Length in mm.	20–25	25–30	30–35	35–40	40–50	50–60
No. examined	9	11	3	4	8	3
Articles of diet: Copepoda	.33	8.17		.5	1.25	
Cladocera	.24				1.	
Ostracoda					3.75	
Midge larvae	85.55	63.27	66.66	97.5	42.35	23.33
May fly larvae		14.09	30.	2.	14.	50.8
Beetle larvae					2.5	
Caddis fly larvae	.55				12.25	23.33
Snails		.9				
Fish remains		4.68	3.34		1.25	
Mites		.09				
Annelid worms					11.25	
Bottom debris	13.33	8.90			10.4	2.64

Midge larvæ and may fly larvæ seem to furnish the main articles of diet for both old and young. The very young show a tendency to incorporate more of the entomostraca in their diet and it is possible that specimens smaller than any of these taken may eat still a larger percentage of entomostraca. In the latter regard there is a slight resemblance to *Percina caprodes* but the change from entomostracan food to insect food is not nearly so well marked in *Diplesion*. Although amphipods were abundant in the localities seined, few appear in the food of *Diplesion*. Two specimens only from Buckeye Lake had eaten more than fifty per cent of Amphipods.

The specimens taken from the streams showed a more varied diet than those from the lakes but the tendency to favor midge and may fly larvæ is still apparent. Silt and debris appear in large quantities in the stream specimens but these may have been taken accidentally while the fish were securing other food.

Summary of food habits in Diplesion blennioides.

1. The earliest stage, which is marked by the consumption of entomostracan food in *Percina caprodes*, is poorly shown in *D. blennioides*. 2. May fly larvæ and midge larvæ constitute the main articles of diet for both smaller and larger specimens. 3. Specimens from streams tend to show a more complicated diet.

C. **Boleosoma nigrum** Rafinesque.

Specimens of this active little fish were taken in nearly every stream and inland lake examined. Tables have been prepared for those from the streams and for those from the lakes, but the habits are so uniform that little of difference is offered in such tables. The younger specimens compare favorably with those of *Percina caprodes* in their selection of entomostraca and minute midge larvæ for food and in their gradual relinquishment of this food to take up may fly larvæ and larger midge larvæ. May fly larvæ and midge larvæ are the only animals eaten by many and these forms are not wholly lacking in the food of any. The constant occurrence and large quantities of silt and debris indicate a selection of this material by the fish for food.

TABLE 6.

Food of *Boleosoma nigrum* from inland lakes.

Length in mm.	20–25	25–30	30–35	35–40	40–50
No examined	6	6	10	9	1
Articles of diet: Copepoda	6.33	6.09	10.1	4.77	30.
Cladocera	20.16	10.33	21.3	11.66	
Ostracoda	2.33		3.1	.83	
Midge larvae	50.83	54.33	44.5	71.66	10.
Amphipods	6.66				
May fly larvae	3.33	10.	2.0	5.55	
Caddis fly larvae					10.
Fish remains	3.33	9.			
Flat worms			1.2		
Round worms		2.	.6	1.33	
Filamentous algae	.5	1.33	.6	.2	
Diatoms	1.7	.26			
Desmids	.33				
Sand and silt	4.5	6.66	16.6	4.	50.

TABLE 7.

Food of *Boleosoma nigrum* from streams.

Length in mm.	15–20	20–25	25–30	30–35	35–40	40–50	50–60
No. examined	4	17	20	10	4	4	1
Articles of diet: Copepoda	40.25	19.04	18.75	12.5	8.25	4.25	
Cladocera	8.25	12.4	7.1	1.5	7.25	1.5	
Ostracoda		2.64	.4	1.	1.25		
Midge larvae	35.75	49.11	50.9	52.3	60.	85.75	40.
May fly larvae	2.	2.94	2.5	12.8			60.
Beetle larvae					7.50		
Caddis fly larvae			.5			1.75	
Snails		.58	1.5	2.			
Fish remains		.3	.5	1.5			
Flat worms		.3	1.5				
Round worms		.82	.85	.5			
Mites		1.					
Rotifers		.17					
Filamentous algae				.8			
Bottom debris	13.75	10.7	15.5	15.1	15.75	6.75	

Summary of Food Habits in Boleosoma nigrum.

1. Entomostraca and minute midge larvæ constitute the chief food of the young. 2. Midge larvæ of larger size and may fly larvæ gradually supplant the entomostraca as the fish increase in size. 3. Organic and inorganic debris forms an important food item in fishes of all ages. 4. Lake and stream habitats do not affect the food habits differentially.

D. **Cottogaster copelandi** Jordan.

Members of this species were taken only from the Bass Island region of Lake Erie where it was the most universally distributed of all the darters. The food habits resemble those of some of the minnows in that a large amount of vegetable material and silt enter into the food. Midge larvæ and may fly larvæ are most commonly taken, but single specimens have been taken whose stomachs were entirely filled with debris and algæ. Another distinctive point is the negligible quantity of entomostraca occurring in the food. This fact, together with the fact also that ostracoda occur frequently, points toward a strict bottom feeding habit. It is also notable that there is little difference in the diet of younger and more mature fish.

TABLE 8.

Food of *Cottogaster copelandi.*

Length in mm.	23	28	30	31	32	34	35	36	37	38	39	40	41	42	44
No. examined	1	1	1	2	3	2	5	3	5	5	5	5	4	5	2
Articles of diet: Copepoda				2.5	+		19								
Cladocera					+	15	1.				+		3.1		
Ostracoda		3.					1.			8.	1.	14.2	.7		
May fly larvae	50.			45.	20.	35.	19.	....	24.	28.	18.	21.4	11.	20.	75.
Amphipods					5.6										
Midge larvae	50.	97.	85.	27.5	69.4	40.	44.	62.6	35.	31.4	23.	28.4	7.	20.	25.
Beetle larvae						10.	4.	1.							
Fish remains			10.					5.		3.	6.	8.			
Fish eggs								3.3	11.	4.6	24.	2.		46.	
Mites				5.											
Filamentous algae			5.	5.				13.1	5.	2.	1.	14.	+	3.	
Bottom debris				15.	5.		12.	15.	25.	23.	27.	12.	78.2	11.	

Summary of Food Habits in Cottogaster copelandi.

1. Midge larvæ and may fly larvæ are the principal articles of diet. 2. Comparatively large quantities of algæ and bottom debris are eaten. 3. Entomostraca are taken only in very small quantities.

E. **Boleichthys fusiformis** Girard.

This fish was taken mainly in the inland lakes, and in some, like the Portage Lakes near Akron, it was the most abundant darter. A few specimens were taken in Lake Erie near Put-in-Bay, but none were taken from the streams of the state.

TABLE 9.

Food of *Boleicthys fusiformis.*

Length in mm.	10–15	15–20	20–25	25–30	30–35	35–40	40–50
No examined	1	24	11	9	9	3	5
Articles of diet: Copepoda	40.	12.83	16.55	2.22	4.44	5.03	.4
Cladocera	60.	22.58	27.36	7.22	8.88	1.66	1.
Ostracoda		9.54	27.27	16.11	7.22		.2
Midge larvae		21.58	17.45	26.70	46.22	10.	30.4
Amphipods		27.25	10.19	13.88	17.33	41.66	11.6
May fly larvae		5.		22.22	4.05		22.
Dragon fly larvae				5.55		8.33	
Corixa nymphs				1.66	3.55		6.
Snails							16.
Isopods						31.66	
Fish remains					1.11		
Round worms					3.33		10.
Insect eggs					1.66		.4
Filamentous algae		.2		1.11	.33		2.
Sand and silt		1.02	1.18	3.33	1.88	1.66	

An examination of the accompanying table shows that *Boleichthys* is a typical darter as far as its food habits go. Beginning with a diet of pure entomostraca they turn to larger food as they grow larger. Amphipods, midge larvæ and other larger insect larvæ begin to appear next in the diet while at the same time the entomostraca become less important in the food.

The diet also becomes more complex with the increase in size of the fish. In all these respects *Boleichthys* resembles *Percina caprodes*. It is remarkable that a fish feeding upon the bottom and in the midst of so much organic debris should take so little debris with its food. In sharp contrast to *Cottogaster copelandi*, which also feeds upon the bottom but takes large quantities of debris and algæ, *Boleichthys* like a true but miniature game fish selects only moving objects for food.

Summary of Food Habits in Boleichthys fusiformis.

1. Entomostraca are the chief food of the smaller specimens but this gradually gives place to larger objects as the fish grows older. 2. The diet becomes more complex with the increase in age of the fish. 3. Amphipods, midge larvæ and other insect larvæ become the important articles of food in the older specimens.

F. **Etheostoma flabellare** Rafinesque

The food habits of this little game fish present some very distinctive features. There are only traces of entomostracan food taken in the smallest specimen. When only 13 mm. in length its food consists entirely of may fly larvæ and the larvæ of midges. The size of the food animals is surprising. Frequently the entire stomach contents was found to consist of a single larva tightly wadded in the stomach. The larva was sometimes nearly as long as the fish. The size of the food increased with the size of the fish when amphipods, beetle larvæ, caddis fly larvæ and corixas were taken. Specimens from the swift streams of the state and those from Lake Erie agreed closely in their food habits but there was a total absence of amphipods in the food of stream specimens.

TABLE 10.

Food of *Etheostoma flabellare* from Lake Erie.

Length in mm.	13	14	15	16	17	18	19	20	21	22	23	24	25	26	35	36	37	40	52
No. examined	2	4	3	4	1	8	5	8	5	4	6	2	3	1	2	2	2	4	2
Articles of diet: Midgelarvae and pupae	3.		3.33	1.2		5.	17.4	5.2	.6	1.2					5.				
Amphipods					60.		10.		14.	2.5	16.6						60.	27.5	
May fly larvae	97.	100.	66.6	98.8	40.	95.	72.6	94.8	85.4	96.3	83.4	100.	100.	100.	95.	100.	40.	38.	25.
Beetle larvae																		33.8	75.
Flat worms			+															.7	

TABLE 11.

Food of *Etheostoma flabellare* from streams.

Length in mm.	10–20	20–30	30–40	40–50	50–60
No examined	5	13	5	1	1
Articles of diet: Copepoda	2.5				
Cladocera	1.				
Midge larvae	49.	60.7	32.	100.	
May fly larvae	47.5	39.3	48.		100.
Caddis fly larvae			8.		
Corixa nymphs			12.		

Summary of Food Habits in Etheostoma flabellare.

1. The food in the younger stages of the fish consists of may fly larvæ and midge larvæ, the food animals being quite large and proportionate to the size of the fish. 2. The larger specimens continue to eat may fly larvæ, the larvæ of midges, the larvæ of other large insects and the adults of amphipods. 3. Amphipods do not appear in the food of the stream inhabiting fish.

G. **Etheostoma cœruleum** Storer

The rainbow darter occurs in swift streams often in company with *Etheostoma flabellare*. The food resembles that of *E. flabellare* in that may fly larvæ and midge larvæ are eaten at all stages after the fish becomes active. Entomostraca are taken in fairly large numbers in the younger specimens but they decline in importance as the fish increases in size. Snails, larger insect larvæ, a few small crayfish, midge larvæ and may fly larvæ make up the diet of the larger specimens.

TABLE 12.

Food of *Etheostoma coeruleum.*

Length in mm	15–20	20–25	25–30	30–35	35–40	40–50
No examined	2	19	15	7	8	4
Articles of diet: Copepoda	40.	17.53	6.93	2.62	.25	
Cladocera		.37	.46			
Ostracoda		.74	.8			
Midge larvae	60.	37.	33.35	35.55	25.12	56.25
May fly larvae		41.85	57.33	52.55	46.25	27.50
Large Dipteran larvae		2.				
Beetle larvae					3.75	
Caddis fly larvae					10.62	
Crayfish					12.14	
Mites						1.25
Snails		.26		9.28		15.
Sand and silt		.25	.13		1.87	

Summary of Food in Etheostoma cæruleum.

1. Entomostraca are taken to a limited extent by the younger specimens but are a negligible factor in the food of the older fish. 2. May fly larvæ and midge larvæ are the chief food in all stages over 15 mm. in length. 3. Larger insect larvæ, snails, and crayfish enter into the food of the larger specimens.

H. **Etheostoma variatum** Kirtland.

Only six specimens of this fish were taken. Three were taken in Little Darby Creek and three in Big Walnut Creek, both branches of the Scioto. One was 33 mm. in length, one 34 mm., two were 35 mm., one was 36 mm. and one 58 mm. Not enough data was secured to warrant any definite statement concerning their food habits, but many fly larvæ and midge larvæ formed the only food of four and the main food for the remaining two. One had eaten 20 per cent of sand and debris and the other had taken a few mites in addition to may fly and midge larvæ.

Summary of food in Etheostoma variatum.

1. In six specimens may fly and midge larvæ formed almost the only food.

I. **Hadropterus aspro** Cope and Jordan.

Eleven specimens of this fish were taken, ranging in length from 34 to 66 mm. They were taken from the following localities: Miami River near Sidney, Plum Creek east of Ft. Laramie, Big Walnut Creek near Columbus, Black Lick Creek near Reynoldsburg, Little Darby Creek near West Jefferson, and from Deer Creek.

May fly larvæ, midge larvæ, corixa nymphs, copepods, fish remains and silt occurred in the stomachs and were so distributed as to leave the impression that there was no prevalent food for a fish of any given length. For example, a 34 mm. specimen had eaten only midge and may fly larvæ, a 39 mm. specimen had eaten 100 per cent of copepods and a 40 mm. specimen had eaten corixa nymphs and small fish. A 66 mm. fish had eaten 60 per cent of copepods, 38 per cent of may fly larvæ and 2 per cent of silt. Corixa nymphs were eaten only by those from Deer Creek and those containing a large per cent of copepods in their stomachs all came from Big Walnut and Black Lick Creeks.

Summary of Food in Hadropterus aspro.

1. The food is quite variable, may fly larvæ, midge larvæ, copepods and corixa nymphs being the most important food animals. 2. There seems to be no change in the food habits of specimens ranging from 34 mm. to 67 mm. 3. There is some evidence that Hadropterus is a random feeder, taking within certain limits whatever chances to be present.

J. **Hadropterus phoxocephalus** Nelson.

This rather rare species was taken only twice. A 53 mm. specimen was taken from the Miami River near Sidney and a 57 mm. specimen from Black Lick Creek three miles north of Reynoldsburg. As in *H. aspro* the principal food animals were midge larvæ, may fly larvæ and copepods.

K. **Ammocrypta pellucida** Baird.

Three specimens of this fish were examined. A 36 mm. specimen from Middle Bass Island near Put-in-Bay had eaten 90 per cent of midge larvæ and a little silt. One 24 mm. specimen from the west branch of the Mahoning River had taken only midge larvæ and one from Beaver Creek near Celina had eaten a little sand and several midge larvæ.

COMPARATIVE FOOD HABITS OF DIFFERENT SPECIES.

The darters belong to the family Percidæ and so are most nearly related to the perch and the pike perch. The darters are a specialized group and so far as the food habits of the young go, there is such a variety of behavior that it is difficult to select a typical mode. The perch is a generalized fish on the other hand and it is practically certain that the darters descended from an ancestral perch-like fish. In seeking for a near relative, therefore, with which to compare the darters we naturally turn to the perch. In this fish there are three well recognized but intergrading stages of food habit depending upon age. The very young subsist almost entirely on entomostraca, turning gradually to amphipods and insect larvæ—mainly midge and may fly larvæ—while the proportion of entomostraca diminishes. Still later, in the yearling and two-year-old perch the diet becomes very complex but there is a predominance of amphipods and large insect larvæ in the food. Snails and vegetable material are also eaten in considerable quantities. These three stages in the food habits of fishes have been shown by Forbes to exist in the perch and in many other fishes, especially the Centrarchidæ which are closely related to the darters and they have been designated as infancy, youth and maturity. In examining the records of the food of the darters to select those showing a typical habit, the three periods are borne in mind and those fish are selected which most nearly conform to this type of habit.

Of the eleven species examined, *Percina caprodes* most nearly meets the specifications of generalization in its food habits. The periods of infancy and of youth are well marked and the period of maturity is marked by an omnivorous habit. It would also be expected also that a fish with a generalized food habit would find survival easy and would therefore be abundant and uniformly distributed. All these requirements are met, indeed the distribution of *Percina* was identical with that of the perch in many places.

Boleichthys may also be ranked as generalized in its food habits. Beginning with entomostraca in the 12 mm. stage, it changes rapidly to amphipods and insect larvæ, never giving up the entomostraca entirely even in the 50 mm. stage. Then it passes to maturity, where the boundary is not so well marked,

but may be recognized by the greater proportion of large sized food animals such as snails, isopods, dragon fly larvæ and corixa nymphs.

Diplesion blennioides passes over the stage of infancy very quickly and begins eating the food characteristic of youth by the 20 mm. stage. There is a strong tendency to take only may fly and midge larvæ on the part of the specimens from Lake Erie, while those from the streams pass into a typical maturity in which the diet becomes more complex and large insect larvæ are taken. It must be admitted, however, that if complexity of diet is to be taken as a criterion of maturity, *Diplesion* reaches maturity by the time that it has reached the 25 mm. stage.

Boleosoma nigrum begins a mixed diet very early (15 mm.). Entomostraca and minute midge larvæ continue to appear in the food through life indicating that the habits of infancy are never entirely given up. There is a marked utilization of debris also which does not occur in any other darter except *Cottogaster copelandi.*

Cottogaster copelandi. No specimens under 28 mm. in length were examined so that it is impossible to give any data concerning the stage of infancy. The period of youth is well sustained up to the 43 mm. stage and in addition there is the development of two habits that mark this group as a specialized one. These habits are the eating of bottom debris and vegetation and the consumption of fish eggs.

Hadropterus aspro. Nothing can be offered as to the habits of infancy in this fish, but the persistence of copepods, midge larvæ and may fly larvæ up to 66 mm. specimens points to a retention of the habits of infancy and of youth in the mature stage. It resembles *Boleosoma nigrum* and *Diplesion blennioides* somewhat in this respect.

Etheostoma. This genus as represented by the three species, *flabellare cæruleum* and *variatum* is characterized in its food habits by its resemblance to the mature game fishes. Vegetation and debris are seldom taken and from the earliest stages (10 mm. in *flabellare*) they capture and eat food animals that are very large in proportion to the fish eating them. Midge larvæ, may fly larvæ, beetle larvæ and corixa nymphs are some of the animals eaten. *E. flabellare* shows the greatest degree of specialization in this direction with *E. cæruleum* resembling it

somewhat. There is a tendency also to omit entomostraca from the food of infancy and to take larger insect larvæ at once. *E. cæruleum* resembles the more generalized darters in this regard, having a large proportion of copepods up to the 15 mm. stage.

The length of the fish has been taken to indicate its age throughout this discussion but it is recognized that the relationship is only relative, especially when comparing members of different species. Thus it appears that *E. flabellare* has passed into the stage of youth by the time that it has gained a length of 10 mm. but *Percina caprodes* does not pass into this stage as indicated by its food habits till it reaches a length of 25 mm. After studying *P. caprodes*, therefore, one is likely to fall into the error of considering the much smaller specimens of *E. flabellare* as correspondingly younger. Indeed, it may be an error in this paper to have stated that the stage of infancy in *Etheostoma* is poorly represented, for it is possible that specimens may be found which are less than 10 mm. in length and which eat entomostracan food.

Summary of Comparison of Food Habits.

The darters may be divided roughly into three classes based upon the character of the food at the different periods in their lives. First: a group with generalized food habits such as those found in the perch and the sunfishes. In this class three periods are to be recognized in the life of an individual; infancy, when the food consists of entomostraca and minute midge larvæ, youth, in which may fly larvæ, small midge larvæ and small amphipods form the food, and maturity during which period the food is varied and is likely to contain a large proportion of large insect larvæ, large amphipods and snails. Second: one in which the period of youth is shortened or omitted and the adults subsist to a considerable extent upon vegetation and debris. Third: a group of miniature game fishes which begin at a very early stage to hunt for large may fly larvæ, midges and other active larvæ. The period of infancy is curtailed so much as to seem entirely absent or is merged with youth. The habit of taking large food animals continues to the adult stages and the habit is accompanied by an unwillingness to take either debris or vegetation.

To the first group belong *Percina caprodes* and *Boleichthys fusiformis*. To the second belong *Cottogaster copelandi* and *Boleosoma nigrum*, while *Etheostoma variatum*, *E. cæruleum* and *E. flabellare* comprise the third. *Diplesion blennioides*, *Hadropterus aspro* and *H. phoxocephalus* are related to both groups one and three and *Ammocrypta pellucida* resembles group three.

FACTORS GOVERNING FOOD CHANGES.

(*a*) *Age and Size of Fish.*

It is obvious that the smaller fish must be limited in their selection of food to such a size as it is physically possible for them to capture, while the larger ones have a greater possibility of choice. Since the size of the fish is dependent on its age, the age must enter into this principle. Records were kept of the size of the food animals taken by *Percina caprodes*, *Etheostoma cæruleum*, *E. flabellare* and *Boleichthys fusiformis* and this record compared with that of the length of the fish. A close degree of similarity was found between the size of the food animals and the size of the fish, which was quite independent of the character of the food.

(*b*) *Seasonal Position of Food Animals.*

Whether the body of water in question is a stream, a small lake or a large lake such as Lake Erie, there is a season cycle in the fauna and the flora. Phyto-plankton develops which furnishes the food for the minute crustaceans and their larvæ and for the larval forms of some insects. Submerged and floating vegetation develops which furnishes food and a retreat for insects, crustaceans and young fish all of which are important in the food relations of the darters. With the warming of the waters winter eggs of various forms hatch and the young forms produced are also important as food animals. Even eggs of insects and of fishes furnish food at certain seasons. Like all other fishes the darters are dependent for the amount and variety of their food upon the seasons in which they develop.

(*c*) *Special Structures.*

Forbes has pointed out that those fishes that retain the habit of feeding upon minute organism in their adult stages are

equipped for the purpose with fine gill strainers. Some of the darters feed upon entomostraca to some extent in the adult stage but there are none that may be classed as feeding exclusively upon very small objects. An examination of the gill strainers in the different species listed here failed to show any marked differences.

The position of a terminal mouth, especially if the lower jaw is projecting, also seems to be correlated definitely with the habit of taking large and active food. *Etheostoma flabellare* is the most specialized in the development of a projecting lower jaw and it has developed the habit of taking large, active food animals more than any other. *Etheostoma cæruleum* is somewhat less specialized in both its food habits and the development of a terminal mouth but it resembles *E. flabellare*. *Boleichthys fusiformis* was taken in a situation where vegetation and debris were most abundant, but a very small trace of either appears on the food. It is a remarkably clean feeder for the environment and seems to have developed nothing of the grubbing habit, although it is bottom feeder.

(*d*) *Special Habits.*

All of the darters are considered to be very agile fish, but even among the members of an active group there are some that are more active than others. The difference in the ability of the fish to overtake and seize food animals would be reflected in the food. Of the list given here *Etheostoma flabellare* is the most active and the large, active food animals that appear in the diet are not taken by any other darter.

The habit of feeding upon the bottom seems to be well established in the adults of most species but there is a difference even here. Some of the fish have developed a habit of grubbing upon the bottom so that a large amount of debris appears incidentally in the food. *Boleosoma nigrum* is one of this sort. Others may live in the midst of debris and select only live, active food. *Boleichthys fusiformis* illustrates this type.

Percina caprodes in its very early stages is a surface feeder like the younger stages of the perch and black bass but as it matures it becomes a bottom feeder. Others like *Etheostoma flabellare* and *Boleichthys fusiformis* seem to be bottom feeders from the time that they hatch. This difference in habits has its

effect upon the food; the diet of the young *P. caprodes* consists of copepods and cladocera while *E. flabellare* and *B. fusiformis* take, in addition to copepods and cladocera, midge and may fly larvæ and ostracods.

(*e*) *Different Habitats.*

Some of the darters are very limited in their habitats. Although a few seem to occur almost anywhere that a fish might be expected to live. *Cottogaster copelandi*, for example, was taken only in Lake Erie; *Etheostoma cæruleum* was confined entirely to swift streams, but *Etheostoma flabellare*, *Diplesion blennioides*, *Ammocrypta pellucida*, *Percina caprodes* and *Boleosoma nigrum* were found in both Lake Erie and the streams of the state. *P. caprodes* and *B. nigrum* may be expected in almost any body of water except in isolated pools. It is obvious that the small animal life of a swift stream and of a lake choked with vegetation must differ and fishes confined to such habitats must also differ in their food habits. Such a difference is much less than might be expected, however.

Percina caprodes, *Etheostoma flabellare* and *Diplesion blennioides* occurring both in Lake Erie and in the streams of the state afford data for a comparative study of the food of the same species of fish in different habitats. Amphipods form an important item of food in the lake specimens of both *E. flabellare* and *P. caprodes*, but they do not occur in the food of stream dwelling forms. Midge larvæ and may fly larvæ are found in the food of both stream and lake specimens, but species differences are common. The same is true of the molluscan diet. Planorbis and Physa were the snails utilized as food in lake specimens but the flat gastropod, Ancylus, was the only snail found in the food of stream darters. Some specimens of *P. caprodes* were found which had taken as many as thirty of the latter snail.

FOOD AND DISTRIBUTION.

With the exception of *Boleichthys fusiformis*, all the darters mentioned in this paper seem to be rather generally distributed. *Boleichthys* has been taken only in the northern part of the state, but there is no peculiarity in the food which could account for this geographical limitation. Locally, however, the character of the food probably determines the range and distribution

of the fish. Taking the food that they do and having the food habits which are characteristic of them, it would not be expected that *Etheostoma flabellare* and *E. cæruleum* would be found in stagnant water. Nor on the other hand, would it be expected that there would be found species like *Cottogaster copelandi* in swift brooks, when it is given to eating large proportions of vegetation and debris.

If any fish were able to adapt itself to several kinds of habitats, it should be one of generalized habits, for specialized habits whether food, reproductive or otherwise, limit the scope of any animal. The wide range, uniform distribution, and common occurrence of *Percina caprodes* are no doubt partly due to the fact that the animal is unspecialized and is able to become adapted to various habitats. The change in food habits as Percina becomes a stream dweller, when it was formerly a lake fish, may be cited as an instance of such an adaptation in food behavior.

SUMMARY.

1. The food of the Ohio darters varies with the fishes. In the most typical cases the young feed exclusively upon entomostraca, turning to midge larvæ and other small insect larvæ later, and when mature feeding upon a varied diet in which ephemerid larvæ and other large insect larvæ predominate. The fish with the most typical food habits is *Percina caprodes*.

2. Some of the darters vary from this habit of eating insect larvæ in the younger stages by apparently omitting the entomostraca from the first stage. These fish are characterized, even in the adult, by the large size of the food animals taken. *Etheostoma flabellare* is the most specialized in this regard with *Etheostoma cæruleum* resembling it.

3. Other darters after passing through a rather typical first and second stage eat a large percentage of vegetable material and organic debris in their older stages. *Cottogaster copelandi* is the most typical one of this group.

4. Amphipods occur regularly in the food of most lake specimens but are entirely lacking in those from streams.

5. When members of a species are taken from both streams and lakes there is a marked difference in the food animals although there is usually a close adherence to the typical food habit.

6. Factors governing the food of the darters are: (a) The age and size of the fish; (b) Seasonal position of food animals; (c) Special structures in the fishes (terminal or ventral mouth, etc.); (d) Special types of behavior of the fish; (e) Different habitats.

7. Different food habits are not sufficient to account for the distribution of the Ohio darters except locally.

LITERATURE CITED

Forbes, S. A.

1878. The Food of Illinois Fishes. Illinois State Laboratory of Natural History, Vol. 1, Bull. 2, p. 71.

1880. The Food of Fishes. Ibid, Vol. 1, Bull. No. 3, p. 66.

1880. On the Food of Young Fishes. Ibid. Vol. 1, Bull. No. 3.

1880. Food of the Darters. American Naturalist, Vol. 14, p. 697.

1888. On the Food Relations of Fresh-water Fishes. Ibid. Vol. 2, p. 475.

Osburn, Raymond C.

1901. The Fishes of Ohio. Ohio State Academy of Science. Special paper No. 4.

Pearse, A. S.

1918. The Food of the Shore Fishes of Certain Wisconsin Lakes. Bulletin Bureau of Fisheries, Vol. 35, Document No. 856.

Pearse, A. S. and Achtenberg, Henrietta.

1920. Habits of Yellow Perch in Wisconsin Lakes. Bulletin Bureau of Fisheries, Vol. 36, Document No. 885.

Turner, C. L.

1920. Distribution, Food and Fish Associates of Young Perch in the Bass Island Region of Lake Erie. Ohio Journal of Science, Vol. XX, No. 5.

NOTES ON THE DODDER GALL WEEVIL, SMICRONYX SCULPTICOLLIS CASEY

HARRY B. WEISS AND ERDMAN WEST
New Jersey Department of Agriculture

Numerous galls were noted on dodder, *Cuscuta cephalanthi* Eng., at Monmouth Junction, N. J., during the first part of August. Upon collecting and cutting some of the swellings open, several beetles were obtained. At this time most of the galls contained larvæ and a few pupæ. The adult was identified as *Smicronyx sculpticollis* which identification was confirmed later by Mr. C. W. Leng. During the last of August quite a few of the galls contain adults nearly ready to emerge; in fact a few beetles will have emerged by this time. However, most of them leave the galls during the first half of September and later in central New Jersey, emergence taking place through a circular opening in the side.

Each gall is single celled and consists usually of a broadly fusiform or subglobular enlargement of the peduncle of the flower cluster, which normally is comparatively thick and fleshy. (Text figure 1.) Many galls were noted which appeared to be enlarged nodes. The completed galls were for the most part subglobular in shape and about four to six millimeters in diameter, while the younger ones were broadly fusiform as a rule. In a few cases the galls were quite irregular due to having been pressed out of shape by contact with the host of the dodder or to having been constricted by the dodder itself. The galls are light yellow to orange in color, a few being somewhat greenish.

LARVA. Length about 2.25 mm. Form subcylindrical, slightly curved, tapering slightly at both ends; sparsely hairy, hairs short; color light yellow, head light brown. Head small, subcircular, slightly depressed; collum absent; epicranial halves separated dorsally by a very faint median suture; front triangular; gula indistinct, membranous; ventral mouth parts fleshy; clypeus and labrum distinct, former transverse; antennæ minute almost obsolete; ocelli absent. Mandibles of biting type, broad across base, bifid at tip with a comparatively minute tooth below the two terminal ones. Maxilla fused with labium to near apex; lacinia simple, fringed with chitinous hairs on inner surface; galea absent; maxillary palpi two-jointed, labium fleshy with

mentum and submentum fused, indistinct; labial palpi one jointed. True legs absent indicated by ambulatory tubercles. Thoracic and abdominal segments each with three dorsal plicæ. Cerci absent. Anal segment wart-like.

PUPA. Length about 2.25 mm. Light yellow, oval. Head and beak bearing several minute hairs. Prothorax dorsally bears a row of about twelve distantly placed chitinous hairs on anterior, lateral, and part of posterior edges; a pair of similar hairs on middle dorsal portion of prothorax; mesothorax with a pair of shorter chitinous hairs arising near posterior lateral edge; metathorax with a similar pair arising from middle lateral portion; each abdominal segment with a transverse dorsal row of distantly placed chitinous hairs; abdomen terminated by a pair of outwardly directed chitinous spines. All hairs arising from tuberculate bases.

Galls on the Dodder, *Cuscuta cephalanthi*

ADULT. *Smicronyx sculpticollis.* This was described by Casey from Indiana, Virginia and Texas. (Ann. N. Y. Ac. Sci. VI, p. 403, 1892). According to Blatchley and Leng (Rhynch N. E. Amer., p. 218) it is known to occur in New Jersey, Long Island, District of Columbia, Illinois, Kansas and Iowa. In Smith's Insects of New Jersey it is recorded from Clementon, August 9, and Sea Isle City, June 11. Blatchley and Leng state that this species is distinguished from its nearest allies by the small densely punctured thorax, narrow hair-like scales

and almost wholly dull red elytra. Many of our specimens had black elytra except for a pale, reddish-brown, broad stripe extending from humerus to apex. The extent of the black or reddish-brown areas appears to vary slightly. It was noted that immature beetles were almost wholly reddish-brown, the black first appearing along the suture and later spreading laterally.

In Rhynchophora of North Eastern America under the species Smicronyx tychoides Lec., (p. 218) there appears the statement, "said to have been bred from galls on dodder, *Cuscuta gronovii*, by Zabriskie" and it is quite probable that this record refers to *sculpticollis* especially as "specimens named *tychoides* in the Leng collection from Long Island proved to be *sculpticollis*.

OHIO ACADEMY OF SCIENCE

ANNUAL MEETING

At a meeting of the Executive Committee, held on December 17th, it was decided to hold the next Annual Meeting of the Ohio Academy in Columbus, April 14th and 15th, 1922. The preliminary notice of the meeting will be mailed by the Secretary about the first of March.

EDWARD L. RICE,
Secretary of the Academy.